Evaluating and Optimizing Emergency Management in High Schools: An Empirical Study from Renqiu City, Hebei Province, China

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Abstract

Campus safety is a top priority in education. In recent years, frequent sudden campus incidents and some schools' failure to handle them promptly and effectively have exposed weaknesses in campus emergency management. Influenced by traditional education, senior high schools overly focus on students' college entrance exam scores, neglecting emergency management of sudden incidents. This leads to improper handling, negatively impacting teachers, students, and the school.

Research on emergency management in China's education system started late. Most studies on campus emergency management focus on colleges and compulsory education, with few exploring senior high schools specifically. However, senior high schools are often boarding schools with dense populations; students face academic pressure and adolescent sensitivity, creating complex situations. This paper sorts out relevant emergency management theories, investigates the current situation and problems of emergency management in senior high schools in Renqiu City, and proposes optimization suggestions.

Field research finds issues in all stages: in the prevention stage, training remains merely formalistic and material reserves are insufficient; in the disposal stage, personnel lack professionalism and responses are slow; in the recovery stage, evaluations are one-sided and responsibility definitions are unclear; in the learning stage, case analyses are fragmented and inter-school communication is lacking.

Corresponding suggestions include building professional emergency reserves, establishing professional teams, improving post-event evaluation and responsibility mechanisms, and constructing a learning and sharing case database.

Keywords

High School Campus, Emergency Management, Index System, Fuzzy Comprehensive Evaluation

1. Research Background

In recent years, school campuses have increasingly become vulnerable to a range of emergencies, including natural disasters, public health crises, and incidents of school violence. These events not only threaten the physical safety of students and staff but also disrupt educational processes and create long-term psychological consequences [1]. High schools, in particular, face elevated risks due to their residential nature, the concentration of adolescent students, and the complexities of managing large-scale populations. However, despite growing global attention to school safety, emergency management in secondary education settings remains under-researched, especially in the context of developing countries [2].

Existing studies on school emergency preparedness have predominantly focused on higher education institutions or primary schools, often overlooking the unique challenges encountered in high school environments [3]. Moreover, most current research emphasizes qualitative analysis or case-based discussion, lacking quantitative tools to systematically evaluate preparedness levels and inform strategic improvements. In this context, constructing a comprehensive and quantifiable emergency management evaluation framework tailored to high schools is both timely and necessary.

This study responds to this gap by developing a four-stage emergency management assessment model-Prevention, Response, Recovery, and Learning-grounded in the 4R crisis management framework and Crisis Lifecycle Theory [4]. Using data collected from five public high schools in Renqiu City, China, this research integrates fuzzy comprehensive evaluation methods, structured surveys, and in-depth interviews to identify current weaknesses and propose evidence-based strategies for optimization.

By offering a hybrid methodology that combines empirical evaluation and policy recommendations, the study aims to contribute to both the academic literature on school crisis management and the practical development of safer educational environments.

2. Research Method

2.1 Literature Review Method

First, a comprehensive review of both domestic and international literature and theoretical achievements related to campus emergency management was conducted to establish a solid theoretical foundation for this study. This review spanned academic databases including CNKI, Web of Science, and Scopus, covering publications from 2010 to 2024. Particular reference was made to Robert Heath's 4R Crisis Management Theory-which encompasses four key phases: Reduction, Readiness, Response, and Recovery-as well as the Crisis Life Cycle Theory, which includes the stages of Signal Detection, Crisis Outbreak, Crisis Escalation, and Crisis Resolution.

The literature review also analyzed empirical studies on school emergency management in East Asian countries with similar educational systems, such as South Korea and Japan, to identify cross-cultural best practices. For example, Japan's emphasis on regular earthquake drills in schools and South Korea's integrated emergency communication systems provided valuable insights for adapting international models to the Chinese context. These theories and comparative analyses form the core conceptual framework guiding the subsequent research design and analysis, ensuring that the study is both theoretically rigorous and practically relevant.

2.2 Questionnaire Survey Method

Second, to obtain empirical data from the field, a questionnaire survey was administered among staff members of five representative high schools in Renqiu City. These schools were selected to reflect a range of characteristics: two urban schools with large student populations (over 2,000 students), two suburban schools with mixed boarding and day students, and one rural school with limited resources. This diversity ensured that the findings would be generalizable across different school contexts.

The questionnaire was designed around several dimensions, including awareness (e.g., "Do you understand the school's emergency response procedures?"), capacity (e.g., "Can you perform basic first aid?"), practices (e.g., "How often do you participate in emergency drills?"), and evaluation of campus emergency management (e.g., "How effective is the school's emergency communication system?"). The questionnaire comprised 35 items, with 20 quantitative questions using a 5-point Likert scale (1 = "Strongly Disagree" to 5 = "Strongly Agree") and 15 qualitative questions requiring short written responses.

A total of 569 questionnaires were distributed, with 516 valid responses collected, resulting in a high response rate of 90.6%. The respondents included teachers (62%), administrative staff (23%), security personnel (10%), and logistics workers (5%), ensuring a multi-perspective dataset. To ensure data quality, rigorous reliability and validity tests were conducted using SPSS 26.0. Reliability analysis showed a Cronbach's Alpha coefficient of 0.951, indicating excellent internal consistency. Validity analysis yielded a KMO value of 0.807, meeting the requirements for factor analysis and confirming good structural validity of the instrument, thereby ensuring the high reliability of the data collected.

2.3 Fuzzy Comprehensive Evaluation Method

Based on the literature review and preliminary investigations, this study developed a comprehensive multi-level and multi-indicator evaluation system for campus emergency management. The fuzzy comprehensive evaluation method was adopted to conduct quantitative assessments, particularly to address vagueness and uncertainty inherent in the evaluation process, such as subjective judgments of "effectiveness" or "adequacy."

In practice, eight experts from relevant fields were invited to independently rate the importance of each indicator level. These experts included two senior officials from the Renqiu Education Bureau with oversight of school safety, three university professors specializing in educational administration, and three experienced high school principals with over 10 years of safety management experience. Using Saaty's 1-9 scale, experts evaluated indicators such as "Risk Early Warning & Control" and "Command System" based on their perceived importance in preventing and managing emergencies.

These expert evaluations were then used to scientifically determine the weights of the indicators through pairwise comparison matrices, with consistency checks to ensure reliability. This rigorous process enabled a systematic and quantitative assessment of emergency management performance across various stages-such as prevention, preparedness, response, and recovery-providing a robust analytical tool for identifying strengths and weaknesses.

2.4 Interview Method

To gain a deeper understanding of the underlying reasons behind the survey data and to capture operational details that quantitative methods might overlook, semi-structured in-depth interviews were conducted with six key personnel from different schools. These individuals included homeroom teachers, security team leaders, and logistics directors. The interviews focused on emergency management processes, challenges, experiences, and suggestions for improvement, aiming to gather rich qualitative data to provide comprehensive support and deeper insights for the study's conclusions.

3. Theoretical Foundation and Indicator System Construction

3.1 The Theoretical Framework Constructed in this Study Integrates the Following Two Core Theories

Crisis Life Cycle Theory: This theory divides the development of an emergency event into four progressive stages: the Signal Detection Stage (latent risks such as aging electrical wiring), the Crisis Outbreak Stage (event occurrence like a fire), the Crisis Escalation Stage (widening impact such as smoke spreading to multiple buildings), and the Crisis Resolution Stage (recovery and reconstruction). It emphasizes the importance of implementing dynamic and differentiated management strategies tailored to each stage of the crisis. For example, during the Signal Detection Stage, risk assessments and preventive maintenance are critical, while during Escalation, rapid communication and resource allocation become priorities.

4R Crisis Management Theory: Developed by Robert Heath, this theory systematically covers four essential components of crisis management: Reduction (focused on risk mitigation through measures like fireproofing), Readiness (focused on resource preparedness such as first-aid kits and drill training), Response (focused on emergency handling including evacuation and communication), and Recovery (focused on post-crisis reconstruction like repairing damaged facilities and providing counseling). This theory provides a clear and structured process-based foundation for the development of the indicator system in this study, ensuring that all phases of emergency management are addressed.

The integration of these two theories allows for both a temporal understanding of crises (Life Cycle Theory) and a functional approach to managing them (4R Theory), creating a holistic framework that guides the design of evaluation indicators and intervention strategies.

3.2 Design of the Indicator System

3.2.1 Design Principles

Systematicity: The indicators should comprehensively cover the entire process of emergency management.

Scientific Rigor: The design should be informed by both theoretical frameworks and expert opinions.

Operability: The indicators should be quantifiable and measurable to ensure practical application.

3.2.2 Structure of the Indicators

Based on the theoretical framework and literature review, a three-level indicator system was developed (Table 1). The first-level indicator is "Emergency Management in Senior High School Campuses." The second-level indicators cover four stages aligned with the theoretical framework: Prevention (A), Emergency Response (B), Recovery (C), and Learning (D).

The third-level indicators consist of 13 specific and detailed items under these stages, each designed to capture critical aspects of emergency management:

Prevention Stage (A) includes Organizational Structure (A1: e.g., presence of a dedicated safety committee), Risk Warning & Control (A2: e.g., regular risk assessments), Training & Drills (A3: e.g., drill frequency and practicality), and Equipment & Supplies (A4: e.g., availability of first-aid kits).

Emergency Response Stage (B) includes Emergency Personnel (B1: e.g., staff training in CPR), Emergency Command (B2: e.g., existence of a unified command center), and Emergency Control (B3: e.g., crowd control measures during evacuations).

Recovery Stage (C) includes Investigation and Assessment (C1: e.g., post-incident reports covering physical and psychological impacts), Accountability Handling (C2: e.g., clear disciplinary procedures), and Infrastructure and Institutional Reconstruction (C3: e.g., repairing damaged facilities and revising protocols).

Learning Stage (D) includes Case Collection and Compilation (D1: e.g., documented case studies of past incidents), Learning and Communication (D2: e.g., inter-school safety workshops), and Event Review and Summary (D3: e.g., annual safety report analyzing drill effectiveness).

Level 1 Indicator	Level 2 Indicator	Level 3 Indicator
Emergency Management in Senior High School Campuses	Prevention Stage (A)	Organizational Structure (A1)
		Risk Warning and Control (A2)
		Training and Drills (A3)
		Equipment and Supplies (A4)
	Emergency Response Stage (B)	Emergency Personnel (B1)
		Emergency Command (B2)
		Emergency Control (B3)
	Recovery Stage (C)	Investigation and Assessment (C1)
		Accountability Handling (C2)
		Infrastructure and Institutional Reconstruction (C3)
	Learning Stage (D)	Case Collection and Compilation (D1)
		Learning and Communication (D2)
		Event Review and Summary (D3)

Table 1. Three-level indicator system

4. Weight Determination Method

4.1 Weight Determination Method

This study employed the Analytic Hierarchy Process (AHP) to determine indicator weights through the following procedure:

Expert Selection: A Delphi panel comprising 6 emergency management experts (3 education bureau officials and 3 university professors) was convened to ensure dual perspectives from policymaking and academic research.

Judgment Matrix Construction: Using Saaty's 1-9 scale, experts conducted pairwise comparisons of indicator importance. Group opinions were integrated via the geometric mean method to form consolidated judgment matrices.

Consistency Verification: SPSS 20.0 calculated the consistency ratio (CR) for each matrix. All matrices passed the consistency threshold (CR < 0.1 per Saaty's criterion), with actual CR values below 0.05.

Secondary Indicator	Eigenvector	Weight	CR Value	Consistency Test
Prevention Phase (A)	1.093	0.26	0.024	Passed
Emergency Response Phase (B)	1.546	0.36	0.024	Passed
Recovery Phase (C)	0.885	0.21	0.024	Passed
Learning Phase (D)	0.669	0.16	0.024	Passed

Table 2. Weight Allocation and Consistency Test Results for Secondary Indicators

(Note: All CR values were significantly below the 0.1 threshold (max CR=0.024), confirming high logical consistency in expert judgments.)

4.2 Analysis of Weight Calculation Results

4.2.1 Secondary Indicator Weight Distribution

Emergency Response Phase (B) received the highest weight (0.36), highlighting its centrality in campus emergency management and validating the critical "Response" dimension in 4R theory. This emphasis reflects the expert consensus that effective real-time action during a crisis is paramount to minimizing harm, aligning with findings from international studies that rapid response reduces casualty rates by up to 40% in school emergencies [5].

Weight ranking of other phases: Prevention Phase (A, 0.26) > Recovery Phase (C, 0.21) > Learning Phase (D, 0.16), reflecting priority differences in pre-event, during-event, and post-event management. The relatively lower weight of the Learning Phase (0.16) may indicate a common oversight in current practices, where lessons from past incidents are

not systematically integrated into future planning-a gap this study aims to address.

4.2.2 Tertiary Indicator Weight Analysis

Phase	Tertiary Indicator Weight Ranking (Descending)	Key Insight
Prevention	Risk Early Warning & Control (A2, 0.39) > Equipment & Supplies (A4, 0.31) > Training & Drills (A3, 0.19) > Organizational Structure (A1, 0.11)	Risk prevention and resource assurance prioritized over organizational development
Emergency Response	Command System (B2, 0.40) > Control Mechanism (B3, 0.38) > Response Personnel (B1, 0.22)	Command system effectiveness outweighs personnel configuration

Table 3. Ranking of Importance of Tertiary Indicators in Different Stages and Core Conclusions

Critical Findings:

In the Prevention Phase, Risk Early Warning & Control (A2) approaches the highest weight (0.39) among response indicators, demonstrating a "front-loaded risk management" philosophy.

Command System (B2) and Control Mechanism (B3) collectively account for 78% of emergency response weights, underscoring the decisive role of standardized procedures in crisis management.

5. Comprehensive Evaluation

5.1 Implementation Process of Fuzzy Comprehensive Evaluation (FCE)

This study adopts the Fuzzy Comprehensive Evaluation (FCE) method to conduct quantitative assessment. The specific steps are as follows:

Establishment of the Evaluation Set:

A five-level evaluation scale was constructed as

V={V1,V2,V3,V4,V5}=V = \{V_1, V_2, V_3, V_4, V_5\} =V={V1 ,V2 ,V3 ,V4 ,V5 }= (Excellent [100], Good [80], Average [60], Poor [40], Very Poor [20]),

which facilitates the transformation of qualitative assessments into quantitative values.

Generation of the Membership Matrix:

Based on 516 valid questionnaire responses, the distribution ratio of each indicator across the evaluation set was calculated (see Table 3).

Example: For the indicator “Training and Drills (A3)”, 31% of respondents rated it as “Average” and 21% as “Poor,” indicating significant shortcomings in practical training.

Computation of Comprehensive Scores:

By applying a synthesis operation between the weight vector WWW and the membership matrix RRR using

S=W∘ RS = W \circ RS=W∘ R, the following stage-wise and overall scores were obtained:

Prevention Stage: 60.4

Emergency Response Stage: 60.4

Recovery Stage: 60.3

Learning Stage: 61.3

Overall Score: 60.5

(This places the overall performance at the lower threshold of the “Average” level, falling short by 19.5 points from the “Good” category.)

The scores across all stages hover around the critical threshold of 60 points, revealing a systemic weakness in the current emergency management practices.

5.2 Diagnosis and Analysis of Key Issues

Management Phase	Problem Dimension	Manifestations & Empirical Data	Score
Prevention Phase	1. Ritualized Training & Drills (A3)	- Only 22% drills involve practical operations - 67% respondents criticized drills as "perfunctory formalities"	58.6
	2. Inadequate Equipment & Supplies (A4)	- 35% fire hydrants show aging problems - 20% emergency medicines expired	59.0
Emergency Response Phase	1. Professional Competency Gap (B1)	- 90% emergency positions are part-time staff - 40% personnel cannot perform standard first aid	59.6
	2. Delayed Command Response (B2)	- Unified command platform absent - 73% cases exhibited low inter-departmental coordination (per interview data)	59.8
Recovery Phase	1. Superficial Damage Assessment (C1)	- 100% schools only document physical losses - Hidden impacts ignored: instructional disruption (avg. 3.5 days/incident), psychological trauma (23% affected)	58.8
	2. Ambiguous Accountability (C2)	- 80% faculty report "unclear penalty standards" - Cross-departmental responsibility shifting >65%	59.2
Learning Phase	1. Deficient Case Database (D1)	- 100% cases limited to school-specific incidents - Emerging regional risks excluded (e.g., cyberattacks, biohazards)	59.6
	2. Inter-school Collaboration Void (D2)	- No specialized exchange activities in 3 years - 92% schools lack emergency management alliances (per Education Bureau archives)	59.2

Table 4. Critical Issues by Management Phase with Empirical Evidence

Systemic Constraints Synthesis:

Prevention Deficiencies: Inadequate resource allocation and drill effectiveness undermine risk preparedness (A3/A4 scores <60).

Response Bottlenecks: Absence of professional capacity and command structures constrains crisis resolution efficiency (B1/B2 = lowest-scoring items).

Recovery Blind Spots: Narrow assessment scope and accountability gaps hamper systemic resilience.

Learning Inertia: Institutional memory ossification and collaboration deficits weaken continuous improvement.

6. Results

This study evaluated the emergency management capabilities of high schools in City S through a comprehensive quantitative assessment framework. The findings reveal several key deficiencies and areas for strategic improvement, summarized as follows:

6.1 Construction of Professional Emergency Reserves

Hierarchical Training System: Schools currently lack structured, role-specific emergency preparedness training. The study proposes a tiered training mechanism-strengthening evacuation command and coordination strategies for homeroom teachers, and providing advanced first-aid training for school medical teams. It is recommended that schools organize at least one complex scenario drill per semester (e.g., an “earthquake-induced stampede”), and integrate virtual reality (VR) technologies to simulate high-stress situations. VR-based training has been shown to significantly improve participants’ knowledge and self-efficacy in emergency response contexts [6].

Intelligent Material Management: Current systems are inadequate for real-time monitoring of emergency resources. The study suggests implementing a "classified coding + electronic dynamic ledger" system to track expiry, location, and inventory status. Emergency supplies, including food and medicine, should be stocked for at least three days per school population and inspected quarterly in collaboration with local health departments.

6.2 Construction of an Intelligent Command System

Deployment of Full-Time Emergency Teams: Most schools lack certified emergency management personnel. The study recommends assigning 2-3 trained professionals per school, with responsibilities spanning risk assessment, incident response, and post-incident review. This model aligns with the core principles of the Incident Command System (ICS), which emphasizes unified command and clearly defined roles [7].

Technological Integration: Schools should develop digital command platforms integrating video surveillance and multi-terminal communication. During the COVID-19 pandemic, such systems enabled rapid identification and tracking of close contacts by combining campus flow data with surveillance information [8].

6.3 Enhancement of Evaluation and Accountability Mechanisms

Comprehensive Evaluation Metrics: The study proposes a multi-dimensional evaluation scale encompassing material loss, duration of instructional disruption, and psychological impact. Involvement of qualified third-party evaluators is essential to ensure objectivity and credibility. Evaluation models like CIPP (Context, Input, Process, Product) provide a solid theoretical foundation for systematized assessment [9].

Precision Accountability System: Schools should clearly define direct responsibilities (e.g., failure to maintain emergency facilities) and indirect ones (e.g., delayed information transmission). A reward-penalty system with allowances for minor faults is advised to ensure accountability while encouraging proactive participation.

6.4 Establishment of a Case Database and Inter-school Collaboration Network

Standardized Emergency Case Database: The study recommends a three-dimensional classification system-“risk type-response process-lessons learned”-to organize past emergency cases. This includes both common on-campus and off-campus threats such as cyber fraud and secondary disasters from extreme weather.

Collaborative Mechanism: It is proposed that the local Education Bureau organize inter-school emergency management forums each semester, supported by an online platform for real-time resource sharing, knowledge exchange, and operational coordination.

7. Discussion

The findings underscore the urgent need for comprehensive improvements in emergency management within high schools in Renqiu City.

First, professional preparedness is underdeveloped. A tiered training system and immersive VR simulations can significantly enhance staff response capabilities, particularly for low-frequency, high-risk emergencies. Prior research has demonstrated that immersive VR training improves emergency-related knowledge retention and behavioral readiness .The training process should adopt a hierarchical training strategy, carefully provide more targeted training content, set clear and distinct goals for each training session, and skillfully and reasonably employ a variety of forms. It is also necessary to timely assess the training results, check the faculty and staff's ability to understand, master and apply the knowledge or skills learned in the training, so as to quickly identify and make up for gaps.

Second, technology is pivotal. Integrated emergency command systems, incorporating real-time data from surveillance and personnel flow, are aligned with international best practices in digital risk governance. These systems mirror ICS principles and have proven effective in crisis events such as pandemics.

Third, evaluation and accountability mechanisms need standardization and flexibility. The inclusion of third-party assessments enhances transparency and credibility, while frameworks like CIPP and responsive evaluation models offer comprehensive approaches that consider both outcomes and stakeholder perceptions .To ensure comprehensiveness in the investigation and assessment process, diversified survey methods should be adopted. These include on-site investigation, where professionals carefully examine the incident scene to collect evidence; questionnaire surveys and interviews to better gather opinions from all parties, which involve designing scientific and reasonable questionnaires to collect extensive information from teachers, students, parents, etc., and conducting in-depth interviews with personnel involved in the emergency response of the incident; at the same time, it is necessary to learn about documentary materials in advance, such as the school's emergency plans, safety management systems, and daily work records, so as to understand the system construction and implementation of the school in terms of emergency management.

Finally, collaborative learning across institutions is essential. A standardized emergency case database fosters institutional memory and provides reference templates for future incidents. Inter-school forums and online platforms can break down silos, promoting collective learning and regional emergency resilience [10].

In summary, a dual strategy-technological empowerment and institutional innovation-is vital for building a robust, adaptive emergency management system in high schools. Future research should extend the sample size and geographic

scope to validate the generalizability of the proposed evaluation framework.

This study also has limitations. It only takes Renqiu City as an example to conduct a preliminary discussion on the current situation of emergency management in high schools. Future research can be further deepened from the following aspects:

(1) Expand the research scope and conduct horizontal comparisons. Extend the research scope to more regions, carry out horizontal comparative analyses, summarize the successful experiences and existing problems of high school emergency management in different regions, so as to provide references for formulating more scientific and reasonable emergency management policies.

(2) Strengthen case studies and summarize experiences and lessons. In particular, conduct in-depth analyses of typical campus emergency cases that have occurred in recent years, summarize experiences and lessons, and provide references for improving the school emergency management system.

(3) Pay attention to the application of new technologies to enhance emergency response capabilities. Actively explore the application of new technologies such as big data and artificial intelligence (AI) in school emergency management, develop intelligent emergency management platforms, improve the scientific and intelligent level of school emergency management, and enhance the efficiency of school emergency management.

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